International Space Station Reliability Analysis

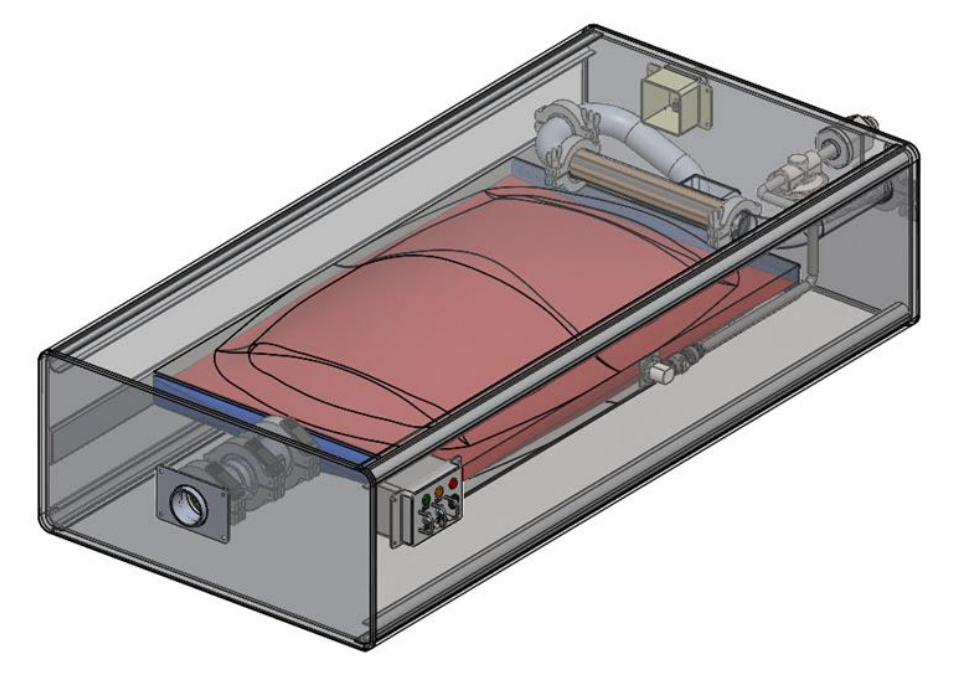
Melissa Bartush
The University of West Florida, Pensacola Florida
Department of Earth and Environmental Sciences

NE/171 Safety Panels Group
International Space Station Division
Safety and Mission Assurance Directorate

Position

- Graduate Student Intern
- ISS Reliability and Maintainability
- Provide reliability data to the ISS program for risk based decisions
  - BPA and EMU Projects

Brine Processing Assembly (BPA)
Qualitative Reliability Analysis



BPA

Problems:

- Class 1E flight hardware for use on the ISS
  - Means no reliability requirements
- Fault Detection, Isolation, and Recovery (FDIR) debate

Failure Mode and Effects Analysis (FMEA)

Brine Processing Assembly

Benefits:

- Identified risk areas
- Input on FDIR discussion
- Co-Mentor will use results to drive design

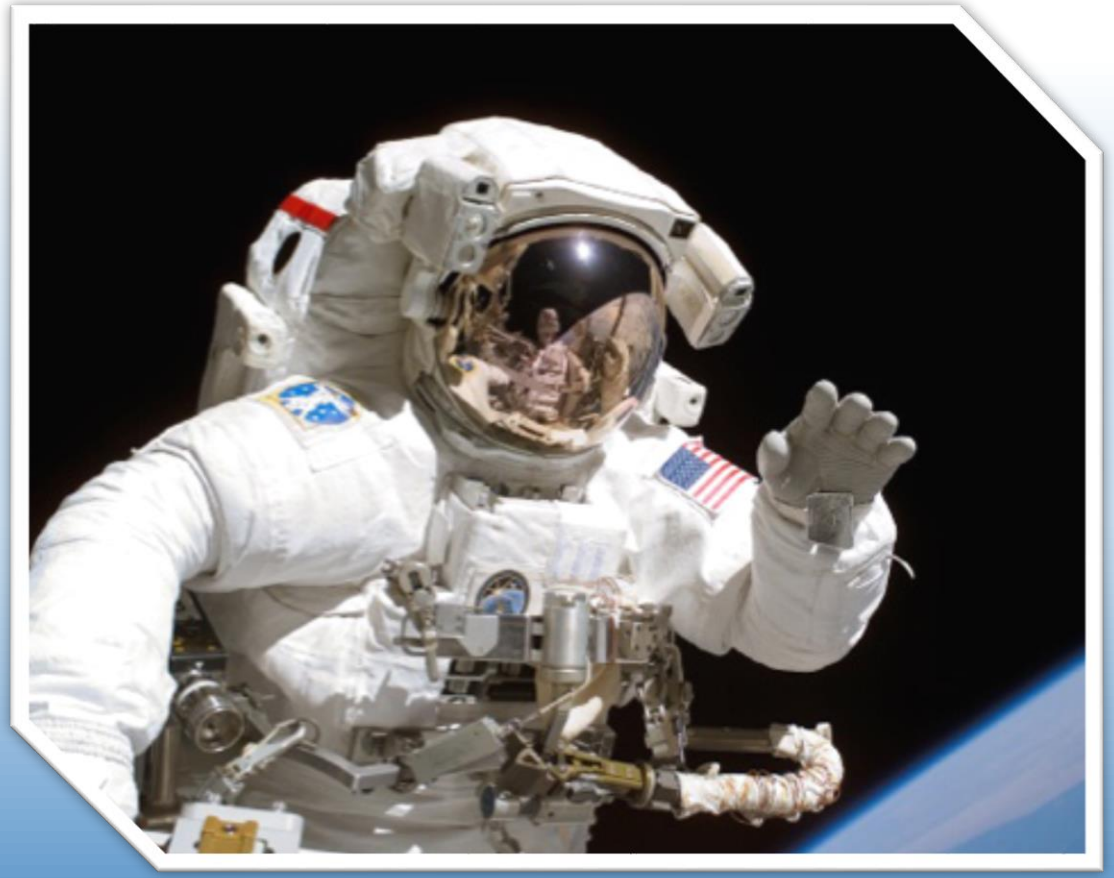
Analysis:

- Failure Modes and causes
- Effects of Failure
- Corrective actions
- Criticality of system

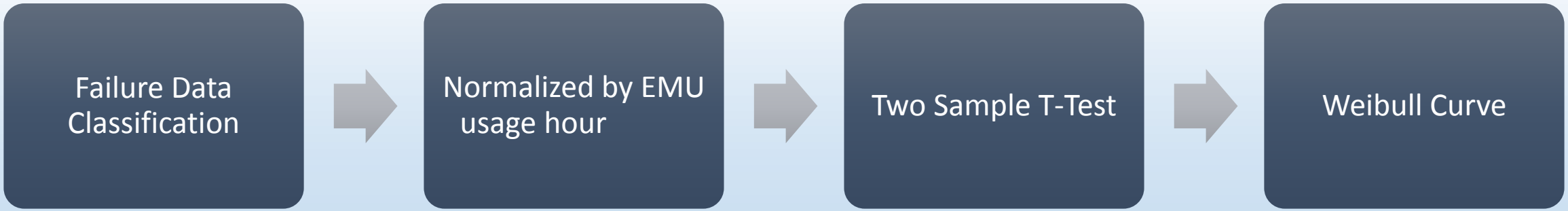
FMEA-CIL
International Space Station

Statistical Analysis
Extravehicular Mobility Unit (EMU)

- Action: Use statistical tools to test the EMU failure data for any trends that are present
- Developed analysis to determine failure rate comparison between maintenance intervals

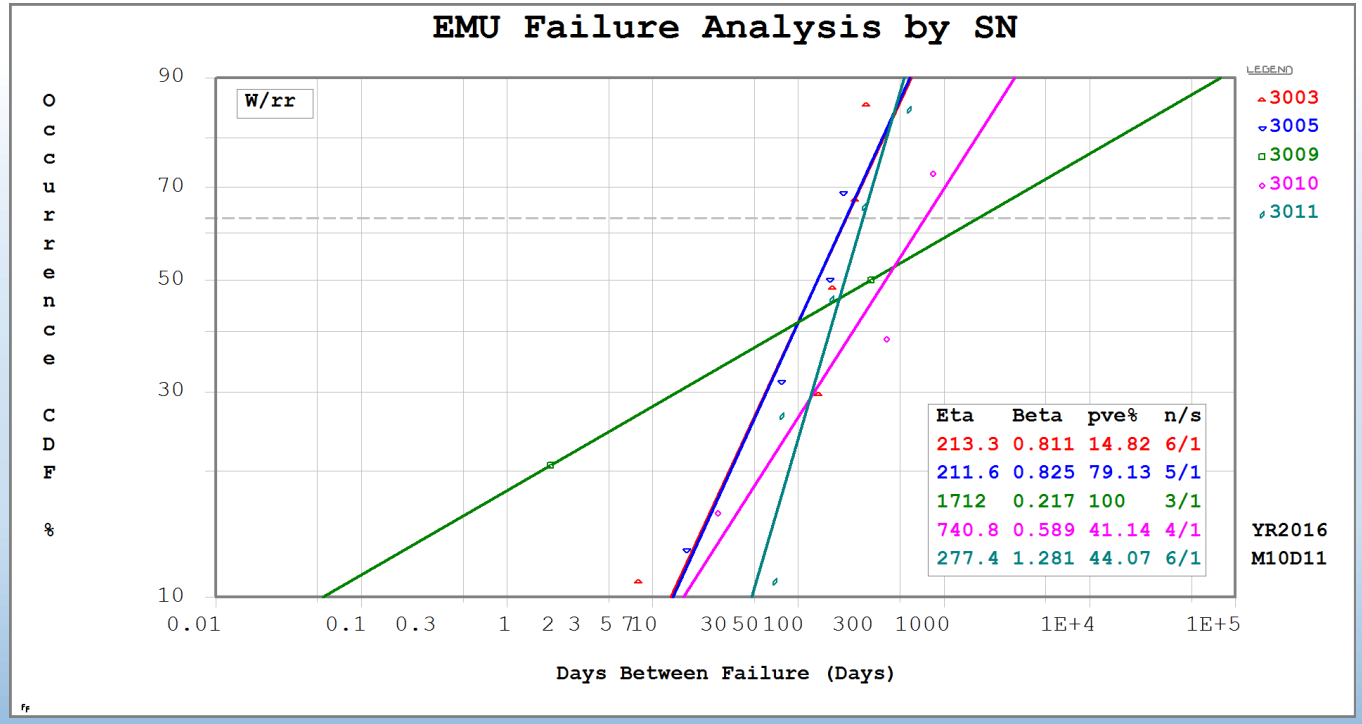


Analysis Steps



Results

- T-Test:
  - Failure Rates (FR) between the two groups are different
  - 6 Year EMU decreasing FR
- Weibull Plot:
  - Overall the EMU has a decreasing FR
  - Each EMU has its own failure curve
  - Insufficient data for individual component analysis
- Reported data and results to EVA Chief Engineer



Professional Growth and Accomplishments

Technical Skills:

- Performing FMEA's to aid in FDIR analysis
- Real world statistical analysis
- Weibull Analysis

Interpersonal Skills:

- Testing knowledge in professional setting
- Confidence by doing meaningful work
- Conflict resolution

The JSC Experience

- Astronauts
- Tours
- ру́сский язы́к

Forward Work

- Apply for NASA Pathways Internships
- Complete Masters degree
- Scout for NASA careers

MANY THANKS

Mentor	Van Keeping
Co-Mentor	Nicholas Meyer
Advisors	Mesha Keuss
	Alan Currie
	Bill McAllister
Internship Coordinators	Veronica Seyl
	Missy Matthias
	Melissa Corning

…And all of my ‘Safety’ family!

Contact information

Melissa Bartush
melissabartush@yahoo.com
850-449-5009

Backup Slides

Normalizing the Data

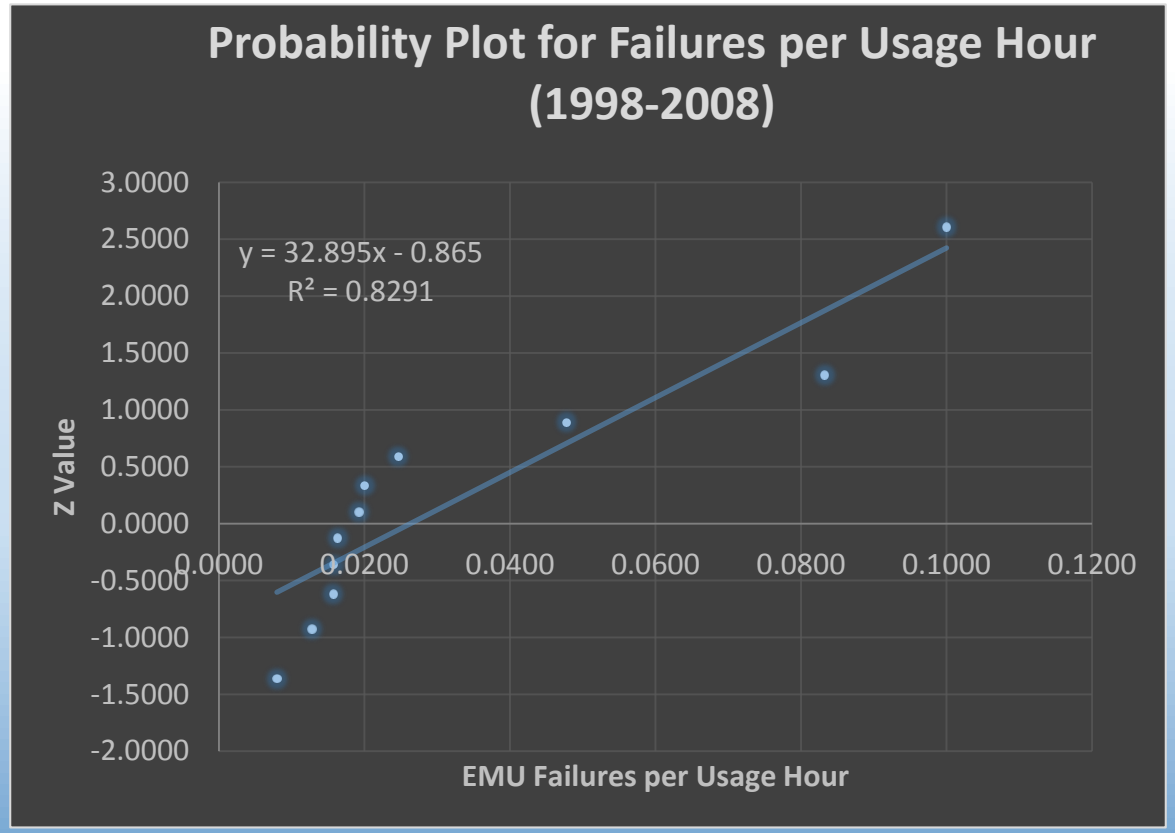
Without Precise maintenance times, the following formula was used to estimate approximate usage hours:

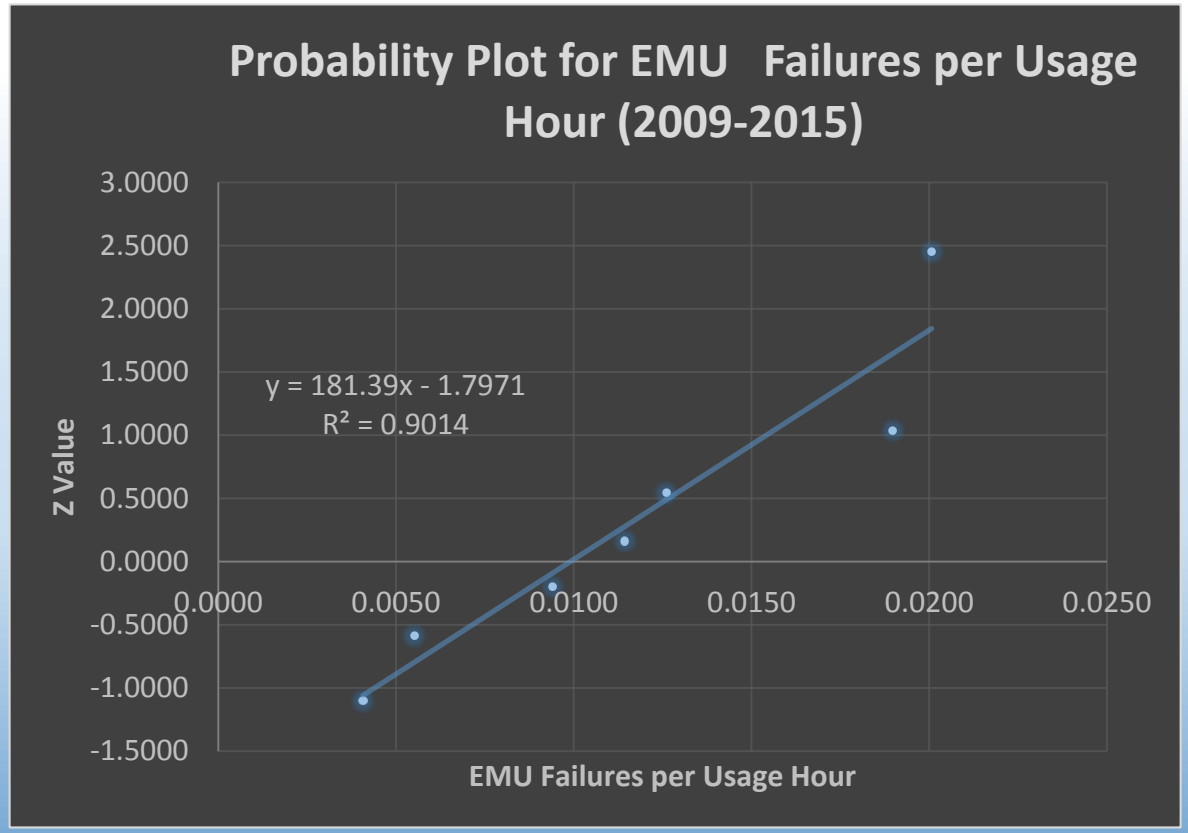
Approximate Usage Hours= Total time on EVA
+Base Maint/Year *(#EMUs on orbit)
+Maint/EVA *(#EMUs on orbit)

Assumption:

- 20 Hours Base Maint/Year
- 20 Hours Maint/EVA

EMU Backup





Normalized non-MEGA and MEGA data

Two Sample t-Test/Hypothesis Test

t-Test: Two-Sample Assuming Unequal Variances

	1998-2008	*2009-2015*
Mean	0.033	0.012
Variance	0.00096	0.000038
Observations	11	7
Hypothesized Mean Difference	0	
df	11	
t Stat	2.219	
P(T<=t) one-tail	0.024	
t Critical one-tail	1.796	
P(T<=t) two-tail	0.048	
t Critical two-tail	2.201	

Note: if t-Stat > t-Critical, reject Null Hypothesis

Result: t-Stat > t-Critical, therefore, at 95% confidence, the test shows that the failure rates between non-MEGA and MEGA EMU's **is** different. It appears that the failure rate actually **decreases** for MEGA EMU.

Scrub criteria:

- Failures that happened in flight or in a flight-like atmospheric situation (such as chamber runs for specific serial numbers in preparation for a specific flight).

PART filter: JSC GFE PRACA, IFI, PRACA

Scrubbed:

NBL Testing	Receiving
Acceptance Testing	NVR Testing
Build-Up	EMI
SSER	Paperwork
Battery	BIO-MED
PIA, UIA	Vibration Test
Glove	Qual Testing
Functional test	Manufacturing
Usage, Expired, Limited Life	METOX

EMU Flight Failures 1998-2008

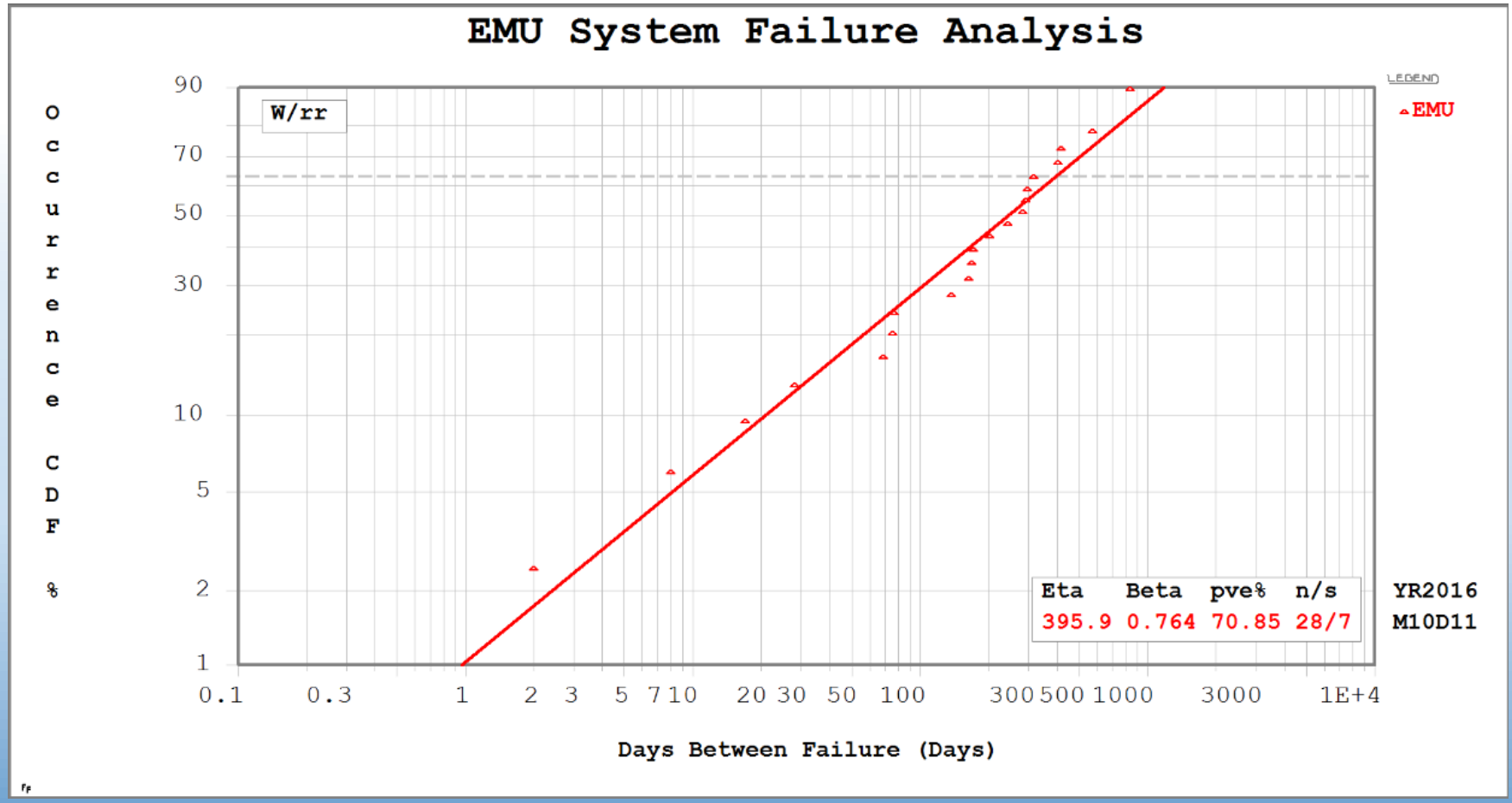
Year	Failures/Year	Total EVA's/Year	Avg Failure/EVA
1998	5	3	1.67
1999	8	1	8.00
2000	10	9	1.11
2001	14	16	0.88
2002	16	18	0.89
2003	7	2	3.50
2004	4	0	0.00
2005	2	4	0.50
2006	8	11	0.73
2007	19	21	0.90
2008	17	15	1.13

EMU Flight Failures 2009-2016*

Year	Failures/Year	Total EVA's/Year	Avg Failure/EVA
2009	12	19	0.63
2010	13	12	1.08
2011	3	7	0.43
2012	2	3	0.67
2013	5	5	1.00
2014	7	3	2.33
2015	8	6	1.33
2016	2	3	0.67

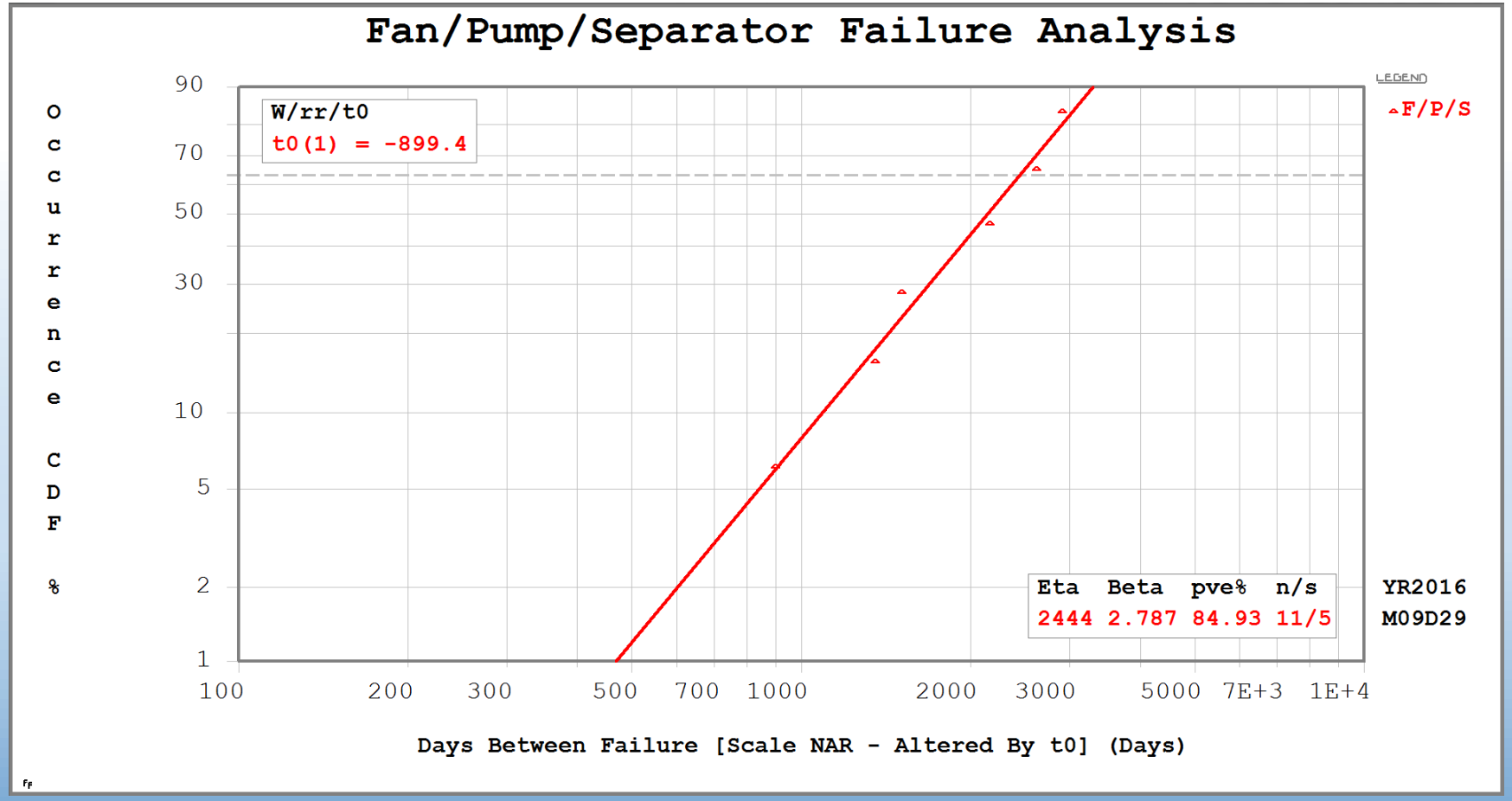
Note: 2016 data included as of end of FY16

Flight EMU



Weibull Plot of EMU system as a whole

Fan/Pump/Separator Failure Analysis



Beta indicates increasing failure rate. It is likely this failure mode is driving the higher beta for 3011.